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Test and Evaluation

OPERATIONAL FLIGHT PROGRAM (OFP)/HARDWARE UPDATE EVALUATION PROCESS

SECTION A. Background

1. PURPOSE. This instruction identifies a best-practice process for AFFTC organizations for evaluating software Operational Flight Program (OFP) and/or associated hardware changes. Associated hardware covers line replaceable units (such as computers/processors/sensors/displays) that interface with the software. It is applicable to all organizations involved in test programs, including tenants and contractors.

2. APPLICABILITY. New test programs should incorporate as much of this process into their structure as possible, and existing test forces should adapt as much of it as possible into their existing organization. The AFFTC representative for new test projects should have the System Program Office (SPO) contract for as much of this process as possible. In addition, this process may be used to evaluate an initial release of an OFP.

3. FACTORS AFFECTING TEST FORCE APPROACH TO FLIGHT TEST OF SOFTWARE CHANGES. Although a test force should endeavor to implement as much of this process as possible, funds and schedule are not unlimited in any test program. Hence there will be tradeoffs in the implementation of this process. Some things to consider when making these hard decisions are:

3.1. Flight Critical Vs. NonFlight Critical Software. Flight critical software affects the guidance and/or control of the vehicle, whereas nonflight critical does not. Due to the immense integration of processors and software on modern aircraft, the lines are blurred between flight critical and nonflight critical software. Flight critical encompasses systems that if not

operating correctly, or if shut down, would jeopardize safety of flight. Some examples of flight critical software are flight control systems, terrain following systems and terrain avoidance systems. One might think that an air-to-ground radar is a nonflight critical system. However, if it were to provide ranging data to a terrain avoidance system, it must be considered flight critical at least for that testing. Levels of redundancy and built in tests need to also be factored in. Each program needs to assess and determine which systems fit into which category.

3.2. Type of Test Program. Implementation of the OFP/hardware evaluation process in a small prototype/research program is relatively easier than in a large production program because of the closeness of the test team members. Implementation in a large production program is difficult because of the diverse population and large inertia that makes flow of information more difficult. Large programs need to be aware of this and fight to overcome it.

3.3. Maturity or Phase of Test Program. As a program progresses and becomes more mature, a conscious decision to lessen some of the requirements and formality of this process may be made. However, the test team must continually evaluate this and be alert for traps waiting to catch them.

4. TERMINOLOGY. Each "Best Practice" will be identified by criticality using the following modifiers:

4.1. Essential: Practices identified as essential are either required by regulations or are considered critical to the AFFTC role in the evaluation of software OFP/hardware changes.

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4.2. Highly Recommended: Practices that have been shown to have the highest payoff potential for contributing to the AFFTC role in the evaluation of software/OFP hardware changes.

4.3. Good Ideas: Practices that have been shown to have some payoff potential but that may have a relatively high cost-benefit ratio in terms of utilization of resources such as manpower and laboratories.

SECTION B. Software OFP and/or Associated Hardware Update Evaluation Process. Figure 1 is a general flow diagram of the process. Each block will be addressed below. Note that the process can be very iterative, and the numerous "inner feedback loops" are not shown. That is, anywhere in the process, if problems/anomalies are encountered, you may have to go back or digress to another point and continue the process from that point.

SECTION C. AFFTC Participation in Primarily Contractor Processes. This section describes the processes that are normally conducted by the contractor, but it is **essential** that the AFFTC test force members participate. The more participation up front in the process, the better the evaluation will be. By so doing, when it comes time to test, the test force will be better able to ensure the OFP change addresses/corrects the root problem identified in the discrepancy or change requirement. The following paragraphs provide participation opportunities for the AFFTC.

5. DEFICIENCY REPORT (DR). It is **essential** that the USAF Deficiency Report (DR) system be used as the formal input through the SPO to the contractor software update process. This process was most recently known as the Product Quality Deficiency Report (PQDR) system and prior to that it was known as the Service Report (SR) system. A DR can be written at anytime, but typically is written when it is apparent the contractor does not intend to fix the discrepancy. At the completion of testing, outstanding issues are reviewed and DRs are written as necessary.

7. CONTRACTOR DISCREPANCY PROCESS. It is a **good idea** to have some informal method for correlating the USAF DR inputs with the contractor's internal discrepancy system. This will ensure that testers can trace the status and resolution of their DRs. It is **highly recommended** that AFFTC engineers be aware of the discrepancies being identified and documented by the contractor in their internal discrepancy system. This can be accomplished at a variety of levels depending on how closely the AFFTC/contractor team normally coordinate on a given project. Some contractors are very reluctant to divulge these internal discrepancies, and SPO involvement may be required to obtain it. Knowledge of these discrepancies can prevent wasted testing and increase flight test safety.

8. NEW USER REQUIREMENT/SPECIFIC CHANGE REQUESTS. It is **highly recommended** that AFFTC engineers be aware of the content and status of Engineering Change Proposals (ECPs) and/or Software Change Requests (SCRs) that are being developed between the SPO and the contractor. This may be the first time the AFFTC will be aware of the impact of user change requirements. It is a **good idea** for AFFTC engineers to review and participate in the ECP/ SCR process.

9. PDR/CDR "AT BUILD" LEVEL. It is **highly recommended** that AFFTC engineers take advantage of any opportunities to participate in the contractor's development process leading up to a design including analysis and testing. Participation in these design stages allows the AFFTC to influence the design so that we have a higher quality product to test later. It is **highly recommended** that AFFTC engineers be aware of the results of the Preliminary Design Reviews (PDRs) and Critical Design Reviews (CDRs) for each software release or "build." This is the first time that a variety of individual changes are brought together in a package. It is a **good idea** for AFFTC engineers to participate in the PDR/CDR process.

10. SOFTWARE CODING. Little or no AFFTC involvement is required/desired during this stage where the contractor is translating PDR/CDR requirements into lines of software code.

11. CONTRACTOR QUALIFICATION TESTING. It is **highly recommended** for AFFTC engineers to be

aware of what the contractor's software Verification and Validation (V&V)/System Integration Lab (SIL)/Lab Testing process and qualification test process is. It is **highly recommended** that AFFTC engineers participate (at an appropriate level) in the contractor's qualification testing. In order to accomplish this, the test force needs to know what testing is being done and when. Minimal (or no) AFFTC participation is recommended for contractor testing at the module level. As the testing proceeds to more integrated system level testing, AFFTC participation is more beneficial. In particular, any testing identified by the contractor as flight qualification testing has the highest payoff potential for AFFTC participation. Flight qualification testing usually includes man and hardware in the loop testing near the end of the test cycle just prior to release for flight. It is **highly recommended** that AFFTC test force personnel be aware of what software/hardware configuration differences exist between the lab and the test article. Failure Modes and Effects Testing (FMET) also has a high payoff potential for AFFTC participation. If participation is not possible, a synopsis briefing/report from the contractor is highly recommended in place of version description documents/detailed report.

SECTION D. Combined AFFTC and Contractor Process

12. COMBINED QUALIFICATION TESTING. Facilities that exist at AFFTC such as the Integration Facility for Avionics System Testing (IFAST), Benefield Anachoic Facility (BAF), Flight Test Avionics Lab (FTAL), and Test and Evaluation Mission Simulation (TEMS) provide the opportunity for combined testing and evaluation of software OFP and/or associated hardware changes prior to and during flight test. In some cases these facilities are "run" by the contractor with AFFTC participation. In other cases these facilities are "run" by the AFFTC with little or no contractor participation. It is **highly recommended** that these facilities be used by both the AFFTC and contractor to maximize the effectiveness of the upcoming flight testing of a particular software change. There are a wide range of options for accomplishing this that are detailed in other documents, such as the Avionics Test and Integration (ATIC) Information Sheet published by ATIC.

12.1 Another type of combined AFFTC and contractor testing that is highly recommended and has been used effectively on several projects is "Confidence Testing." The purpose of these tests is to provide CTF management with additional confidence that a given software release is indeed ready for flight test. These tests can be conducted either at the EAFB facilities previously described or at the contractor's main facilities. These tests are usually conducted after all of the "normal" testing has been completed but before the software is approved for flight test. The primary difference between confidence testing and all of the previous testing is that the confidence test plan is produced by flight testers as opposed to designers. This tends to give the testing a different "slant" that can often uncover discrepancies that were not observed by the normal test process. The flight testers contributing to this test plan can be both AFFTC and contractor engineers and pilots.

SECTION E. AFFTC Process. This section describes the process that is normally conducted by the AFFTC members of the test force but usually also includes participation by the contractor members of the test force.

13. TECHNICAL INFORMATION ACQUISITION. It is **highly recommended** that the worker level test force personnel gather technical information on what the changes are at the build level in order to present the information to test force management personnel. A **good idea** to accomplish this is for the designers and testers to sit together and do an informal "walk through" design level description of the change, the reason for the change, what is expected from the change, and its compatibility with other software/hardware. This is the first opportunity for the tester to start defining the actual testing that will be necessary. A normal product of this phase is a version description document from the contractor, which may or may not have value. It is **highly recommended** that the test force find out what the contractor's general V+V process is, and it is a good idea to know exactly what V+V the specific OFP will go through.

14. PRELIMINARY TEST FORCE MANAGEMENT REVIEW. Around the time of the software/hardware CDR, it is **highly recommended** that the test force conduct a management review to ensure awareness of upcoming software/hardware changes and schedules, so that flight test implications can be assessed.

15. FLIGHT TEST PLANNING.

15.1. It is **highly recommended** that flight test planning begin soon after a software/hardware change is being solidified (PDR/CDR). It is **essential** that the impacts of the software change on flight testing be identified and planned. These impacts include aspects such as test conditions and procedures, operating limitations, and emergency procedures, instrumentation, range requirements, and safety.

15.2. Regression flight testing means different things to different people. Usually regression flight testing means repeating a test that has already been conducted with a previous version of the software. Usually the majority of those repeat tests are aimed specifically at the areas where changes are expected (hopefully improvements). Sometimes regression flight testing includes a "core" set of tests that are repeated every time a software change is made even when that change is not expected to affect the areas in the core test. Core tests may be appropriate when there is uncertainty in the software mechanization and testing process (or a history of unexpected results). Core tests may not be needed in flight if analysis shows that software change impacts can be limited to certain areas or functions, such as redundancy management and modifications to executive code. If a software change dictates an entirely new test condition or procedure that had not been previously flight tested, then that new test cannot be considered regression testing, and associated test planning and review will be required.

15.3. It is **highly recommended** that the core regression test be defined in the original OFP test planning. By so doing, the test force can alleviate its requirement to re-test plan these core tests when a new OFP or associated hardware is released.

15.4. Both a technical review and safety review are necessary as required IAW current AFFTC regulations. Each change will be reviewed individually to determine if it is within scope of the original planning. If regression testing has been identified and planned adequately in the original test planning/technical review/safety review, no further action may be required. If OFP change specific testing beyond this originally defined regression testing is required, the test team must identify the change - specific regression matrix. Technical Review Board (TRB) and Safety Review Board (SRB) reconvenes are more likely to be needed for flight critical changes than for non-flight critical changes. It may not be required to reconvene these boards but it is likely that a paper trail (AFFTC Forms 5232b and 5028 Amendment) will be needed

to document the approach to flight testing the software change. If a new test plan is generated, full technical and safety reviews will be required. It is **highly recommended** that the Test Force produce a consistent framework for the software change process so that judgments on the proposed test approach will be easier to make. This consistent framework should include a clear philosophy for "regression" flight testing.

15.5. There has been confusion in the past about what safety risk level is appropriate for regression flight testing. One philosophy is to use the same risk level as the original test. This philosophy has been applied when the original test was considered a hazardous "envelope expansion" test. Another philosophy that may be appropriate is that most of the "risk" was assumed when the original test was conducted and that the repeat test is therefore at a lower risk level. Either philosophy may be used as long as it is applied consistently and clearly identified in the safety paperwork.

16. IDENTIFY IMPACTS OF QUALIFICATION TEST RESULTS. It is considered **essential** that the flight test impacts of all qualification test results (such as lab, SIL, V+V, IFAST, TEMS, etc.) be identified and that those impacts be considered in flight test planning and briefed to the key flight test participants. A given software change may not function as originally intended and that unplanned effect may impact flight test safety and efficiency. These unplanned effects may not be considered significant (from a specification viewpoint) by the qualification testers, but they may not be fully cognizant of flight test impacts. These impacts could be changes in test procedures, operating limits (Flight Operating Limits Document (FOLD), Airframe and Engine Operating Limit (AEOL), Aircraft Operating Limit (AOL), etc.), or emergency procedures. Simulation/lab fidelity should be considered when analyzing test results. Dedicated reviews of the qualification test results of the new software by flight testers are **highly recommended** in order to increase the probability of identifying flight test impacts. This review could range from a formal meeting to a sequential desk top review.

17. FINAL TEST FORCE MANAGEMENT REVIEW.

17.1. Prior to installation of new software/hardware on the test vehicle it is **essential** that the test force complete a formal management review process that has cross discipline coordination to assess the overall readiness to begin flight testing of that software/hardware. At test forces with less mature test vehicles this review is normally part of the test

force Configuration Control Board (CCB). At test forces with more mature test vehicles this review may be conducted by the members of the CCB without a formal convene of the board. Additionally, this CCB authority may have been delegated to the test force by the AFFTC CCB. This review process should consider topics such as:

- Overall software/hardware change summary
- Qualification test results and impacts
- Open discrepancies
- Flight test planning
 - Test procedure impacts
 - Technical and Safety Review results
 - Ground test prerequisites
- Specific impacts on operating limitations and emergency procedures
- Paperwork status
- Other software/hardware that is compatible/incompatible with the test OFP/hardware

17.2. If a formal CCB is convened, it is a **good idea** to have the designers and/or qualification testers present the software change summary, qual test results, and open discrepancies. It is **highly recommended** that either the contractor or AFFTC flight testers present the topics on flight test planning and on operating limitations and emergency procedures impacts.

17.3. Much of the information needed to support this review is not usually available until very near installation of the new software on the aircraft and right before flight test. Therefore much of the "homework" and preparation for flight test should already be completed. Any open items should be identified at the review and a closure plan established. One of the main goals of the review should be to determine if anything has "slipped through the cracks."

18. AIRCREW TECHNICAL ORIENTATION. It is **highly recommended** that a dedicated briefing to the aircrew be conducted just prior to flight testing with the new software. This briefing should cover many of the same topics as the management review but with special emphasis on the aircrew perspective versus the programmatic perspective. It is **highly recommended** that this briefing include as many of the potential flight test crewmembers as is feasible. A **highly recommended** alternative to a briefing is a written summary that is made a Unit Flight Crew Information File (FCIF) item. It is **essential** that the first aircrew to test new software be aware of all changes with the potential for impacts perceivable by that aircrew.

19. FLIGHT PREPARATION.

19.1. Installation checks and on-aircraft ground tests are usually conducted as a normal part of flight preparation for new software/hardware, such as checksums/configuration verification. It is **highly recommended** that the management review determine if these checks and tests are both necessary and sufficient.

19.2. Simulator dry runs are **highly recommended** prior to flight test of new software. These dry runs are different than confidence testing in that the actual aircrew planned for the test should accomplish the dry run whereas any qualified aircrew may conduct the confidence testing. It may be possible to combine the confidence test and the dry run if the aircrew is the same. The dry runs may be conducted either at the contractor's simulation facility or at an AFFTC facility.

19.3. It is **essential** that the flight briefing emphasize the primary impacts of new software and the expected results. This briefing will be much more effective if a more detailed pilot briefing had been conducted previously. It is **essential** that the OFP ID/checksum be included on the test cards and that the aircrew check that the correct OFPs are loaded prior to flight. It is **highly recommended** that the test force build a

matrix to show what OFPs/hardware are compatible/incompatible with other hardware/OFPs to aid in the preflight preparation. It is **highly recommended** that a one or two page summary of the new software be included with the test cards and that regression testing be explicitly identified. If regression testing must be completed before continuing on with other test cards that should also be clearly identified.

20. FLIGHT TESTING. Actual flight testing of new software should be reasonably safe and effective if all of the essential practices, most of the highly recommended practices, and some of the good ideas are followed. Unexpected results may still occur but at least a reasonable effort will have been made to minimize the likelihood or impact of those unexpected results. These unexpected results may drive the test team back into this OFP/Hardware Evaluation Process at any point to "reaccomplish" the process.

21. OT&E CERTIFICATION/FLIGHT MANUAL INPUTS. It is **highly recommended** that any special constraints imposed by new software on operational testing be clearly identified in the OT&E Certification documentation. It is **essential** that any unique impacts of new software be documented in the flight manual for use by operational crews.

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